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FLUCTUATION OF THE VOLTAGE OF BATTERIES DURING CHARGING WITH AN ASYMMETRICAL ALTERNATING CURRENT

V. V. Bayunov

Army Foreign Science and Technology Center
Charlottesville, Virginia

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DEPARTMENT OF THE ARMY
U.S. ARMY FOREIGN SCIENCE AND TECHNOLOGY CENTER
220 SEVENTH STREET NE.
CHARLOTTESVILLE, VIRGINIA 22901

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AUTHOR: V. V. Bayunov, Doktor Tekh. Nauk M. A. Dasoyan
LANGUAGE: Russian

REQUESTOR: AMXST-GE Mr. Busi
TRANSLATOR: Leo Kanner Assoc.
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Abstract:

The authors discuss the basic parameters of batteries being charged with an asymmetrical alternating current. Particular emphasis is placed on chemical reactions within silver-zinc and lead-acid batteries.

Key Words:

Electronics R and D
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More and more in the technical literature means of charging silver-zinc and lead-acid batteries with various forms of an asymmetrical alternating current are explained.

The basic advantages of the new means of charging lead-acid batteries are the increase of their discharge capacity and the decrease of the duration of charging [1-4]. As has been established, [2,4], during the formation of grids and the charging of batteries with an asymmetrical alternating current in a given electrode, the content of an energy-containing tetragonal modification of lead dioxide increases. Besides that, the positive effect of an asymmetrical alternating current may explain [3] the sharp lowering of diffused terminations and electrode polarization taking place in this instance.

The use of the new means of charging silver-zinc batteries raises their discharge capability and reliability and decreases the duration of charging [5, 6]. Charging with an asymmetrical alternating current also decreases the initial charging voltage. An increase of electrode capacitance may explain the increase of utilization coefficient of the active mass as a result of the improvement of diffusion conditions of the electrolyte and partial or complete removal of diffused terminations. In the work [8] the increase of capacitance is explained by the appearance of an additional formation route of silver oxide AgO as a result of the break-up of the higher silver oxide Ag_2O_3. The increase in reliability of the silver-zinc battery [6] is explained by a decrease in the formation of zinc dendrites.

The lowering of the charging voltage, coupled with the disappearance of the area of silver oxide on the discharging line, is dependent on the development of silver oxide forming on the surface of particles of silver semi-oxide Ag_2O during the negative half-time. During the discharging of the electrode, the surface layer of Ag_2O discharges and converts to metallic silver, which, being located in contact with silver oxide formed

during charging, reduces it to Ag_2O, and further charging proceeds without its participation. The oxide AgO, although formed during charging, actually does not participate in the discharge process, and for this reason areas of silver oxidation are not found on the discharge line.

During charging with an asymmetrical alternating current battery voltage does not remain constant, as during charging with a direct current, but begins to fluctuate in relation to the periodic charging and discharging impulses; that is pulsation voltage develops. Considering that during charging of storage batteries in several systems a part of the consumers continue to be supplied, it is essential to determine the surge voltage, an increase of which may influence the work of the apparatus.

For supplying direct current for various devices, rotating and static transformers are used. The maximal relative voltage pulsation of rotating transformers makes up 2-4% of the increase of the discharge voltage, and in the non-filtered static transformers 25-30% of the rectified voltage [7]. In this work pulsation is determined as the ratio of the average value of amplitude pulsation to the discharge or rectified voltage.

Voltage pulsation was measured during charging of silver-zinc batteries of the type STs -70 and lead-acid batteries of the type ST-70 with an alternating asymmetrical current using a 3-phase transformer [Drawing 1]. In the course of the entire charge, oscillographing of the parameters of the asymmetrical current and the voltage of batteries U_1 and U_2 was carried out on the basis of representative points of the discharge line.

The asymmetrical alternating current was controlled according to the following parameters: the direct component of the current $I_=$ in each parallel circuit, the alternating component of the current I and the relation of the alternating component to the direct $\frac{I_\sim}{I_=}$. The value of the direct component of the current is $I_=$ or the densities of the current according to the direct component $j_=$ vary within wide limits, while the value of the ratio of components $\frac{I_\sim}{I_=}$ in all cases was exactly 6 or 2.

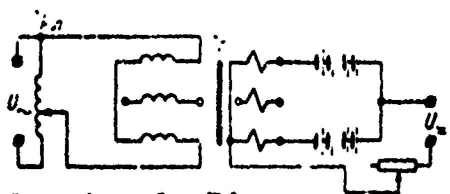
According to the data of the oscillograms, relative ΔU in percentages and absolute ΔU_m in volts, the optimal increase of pulsation was determined by using the following formulas:

$$\Delta U = \frac{U_{max} - U_{min}}{2U_p} \cdot 100; \qquad [1]$$

$$\Delta U_m = \Delta U \cdot U_p, \qquad [2]$$

where U_{max} U_{min} -Maximal and minimal value of voltage in the battery in the course of one period;
U_{p} -Voltage in the battery during discharge of direct current, equal to the direct component of the asymmetrical alternating current.

Change of the relative voltage pulsation of the silver-zinc battery during discharge by various regimes is shown in figure 2, a, from which it is evident that the voltage pulsation rises in all regimes in the course of the first and second stages of discharge.



Drawing 1. Diagram of charging batteries STs -70 and ST-70 with an asymmetrical alternating current. T_{pk} -Laboratory Transformer.

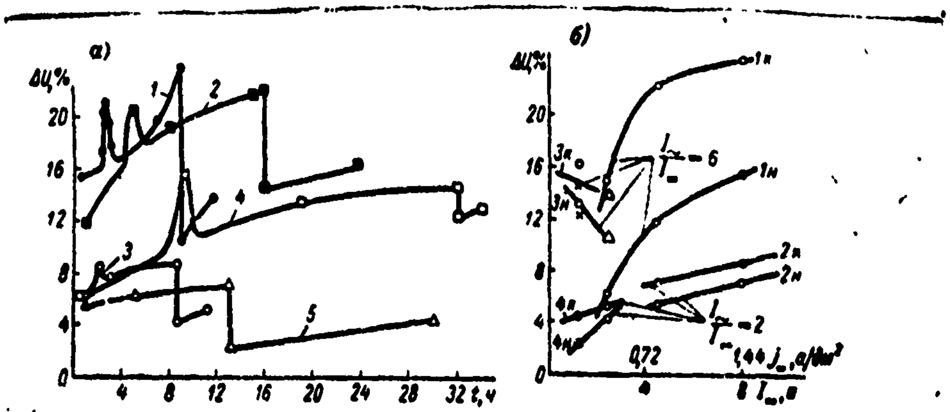
Besides this, in the first stage of discharge, during the course of time of the period of voltage U=1.7-1.92v from the area of silver semi-oxide to the area with silver oxide, there is a point of extreme increase of pulsation.

The maximal value of the extreme voltage pulsation on determined regimes of discharge may even exceed the voltage pulsation at the end of a given regime. In dependence on the increase of the direct component of the current, the duration of the extreme is exactly 0.3--1 ch. The extreme value of voltage pulsation in batteries in parallel circuits develops non-synchronously as the result of the non-synchronous advance of the discharge from the area of single valence silver semi-oxide to the area of silver oxide. During the indicated transfer internal battery resistance develops as the result of the appearance of unstable silver oxide compounds[6], which are in fact the reason for the appearance of the voltage pulsation extreme.

The dependence of voltage pulsation on the density of current by the direct component for various parameters of the asymmetrical alternating current is introduced in drawing 2,b. Since for the normal discharge regime [see drawing 2,a, line 5] the optimal relationship is $\frac{I_{\sim}}{I_{=}}=6$, the maximal voltage pulsation for a given regime at the end of the first stage makes up 22%; that is it does not exceed the voltage pulsation of the static transformers. A signif-

icant development of voltage pulsation on the whole is observed at the time of the first stage of discharge of a given regime and comprises 10%, development at the second stage comprises 2%.

Change of voltage pulsation in the course of charging group A acid batteries is illustrated in drawing 3, a, and change of pulsation dependent on the density of current by direct components of an asymmetrical alternating current--drawing 3, b.



Drawing 2. Voltage pulsation change of batteries of the type STε-70 during charging with an asymmetrical alternating current with various values:
a-components $\frac{I_{\sim a}}{I_{-a}}$

1st stage: Line 1-$\frac{48}{8.0}$; Line 2-$\frac{27}{4.5}$; Line 3-$\frac{16.0}{8.0}$

Line 4-$\frac{14.4}{2.4}$; Line 5-$\frac{9.0}{4.8}$; 2nd stage: Line 1-$\frac{14.4}{2.4}$

Line 2-$\frac{7.2}{1.2}$; Line 3-$\frac{4.8}{2.4}$; Line 4-$\frac{7.2}{1.2}$; Line 5-$\frac{2.4}{1.2}$

b-Density of current by direct component j=

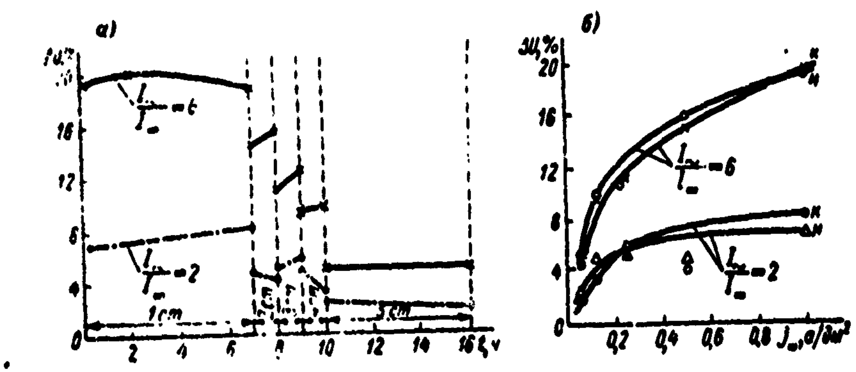
1st stage: 1H,1K,2H,2K; 2nd stage: 3H,3K,4H,4K

H-Beginning of stage; K-end of stage res.

As it is seen from the drawings, the voltage pulsation of batteries develops with the increase of direct and alternating components of the current, and, as a rule, at the beginning of every stage of charging is lower by comparison with the terminal stage of charging by 1-2%. The maximal voltage pulsation for a regime of charging with a current density of a direct component $j_{=}=1.0$ a/dm and the ratio $\frac{I_{\sim}}{I_{=}}=6$ comprises 19%. The effectiveness of charging lead-acid batteries with an asymmetrical alternating current increases with the approach of the form of the

of the current to the pulsating aspect; that is $\frac{I_\sim}{I_=} = 1 \div 2$; therefore the voltage pulsation for all stages of charging when $\frac{I_\sim}{I_=} = 2$ does not exceed 7-8%, and when $\frac{I_\sim}{I_=} = 1$ will be even lower and approaches the maximal increase of voltage pulsation of direct current machines.

Measurement of voltage pulsation during charging with an asymmetrical alternating current on the schema of drawing 1 was also carried out for high capacity lead-acid batteries [group b]. Power limits of elements of the schema allowed the accomplishment of charging regimes of group b batteries only for the ratio $\frac{I_\sim}{I_=}$, exactly 1 and 2.



Drawing 3. Change of voltage pulsation of batteries of the type ST-70 during charging with an asymmetrical alternating current: a-with various values of the ratio $\frac{I_\sim}{I_=}$; -in dependence on the density of the direct component j= . cm-stage of charge.

Data on voltage pulsation is illustrated in the following table.

PULSATION OF BATTERY VOLTAGE IN VARIOUS REGIMES OF USE

BATTERIES	$\frac{I_\sim}{I_=}$	ΔU, % at $j_=$, a/dm²				
		0,045	0,091	0,182	0,273	0,364
GROUP A	2	2,0	3,6	5,0	6,1	—
GROUP B	1	0,7	1,5	3,0	4,6	6,1
	2	1,0	2,2	4,6	6,2	—

As follows from the table, during charging of lead acid batteries of groups A and B with identical parameters of an asymmetrical alternating current, voltage pulsation has a sufficiently similar value.

Conclusions

The maximal voltage pulsation of silver-zinc batteries during charging with an asymmetrical alternating current with optimal parameters comprises 22%; that is does not exceed the pulsation of static transformers.

During charging of silver-zinc batteries with an asymmetrical alternating current, at movement from the area of silver semioxide to the area of silver oxide there is seen to be an extreme increase of voltage pulsation, the size of which may exceed the maximal value of pulsation for a given regime.

The maximal voltage pulsation of lead-acid batteries during charging with an asymmetrical alternating current with optimal parameters comprises 7-8%.

According to preliminary data, the increases of voltage pulsation of lead-acid batteries of various capacity with equal parameters of an asymmetrical alternating current are about identical.

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